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(54) **FLYBACK APPARATUS WITH VOLTAGE  
SUPERPOSITION CIRCUIT AND  
OVERPOWER PROTECTION**

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(2013.01); **H02H 3/087** (2013.01)

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CPC ..... H02M 1/32; H02H 3/08; H02H 3/087;  
H02H 3/093; H02H 3/10; H02H 3/105  
See application file for complete search history.

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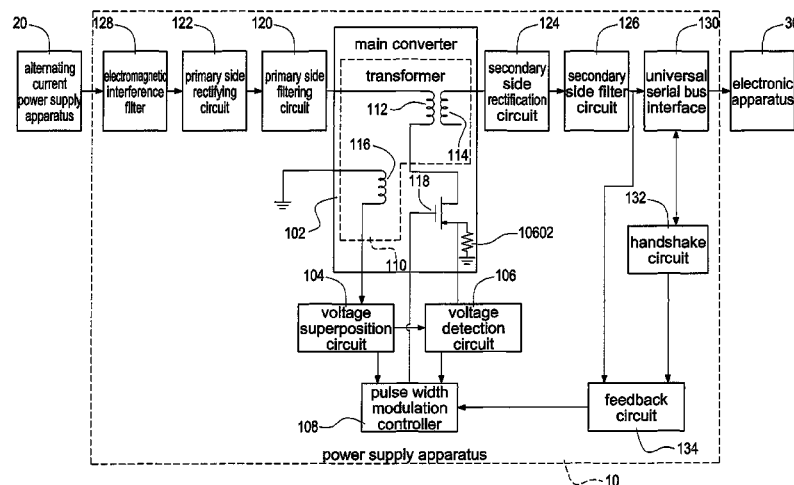
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(57) **ABSTRACT**

A power supply apparatus includes a main converter, a voltage superposition circuit, a voltage detection circuit and a pulse width modulation controller. The voltage superposition circuit is electrically connected to the main converter. The voltage detection circuit is electrically connected to the main converter and the voltage superposition circuit. The pulse width modulation controller is electrically connected to the main converter and the voltage detection circuit. The main converter includes a sensing resistor. The voltage detection circuit detects a sensing voltage of the sensing resistor. The voltage superposition circuit supplies a superposition voltage to the voltage detection circuit when an output voltage of the power supply apparatus is less than a predetermined output voltage, and then the voltage detection circuit sends the sensing voltage and the superposition voltage to the pulse width modulation controller.

**10 Claims, 4 Drawing Sheets**



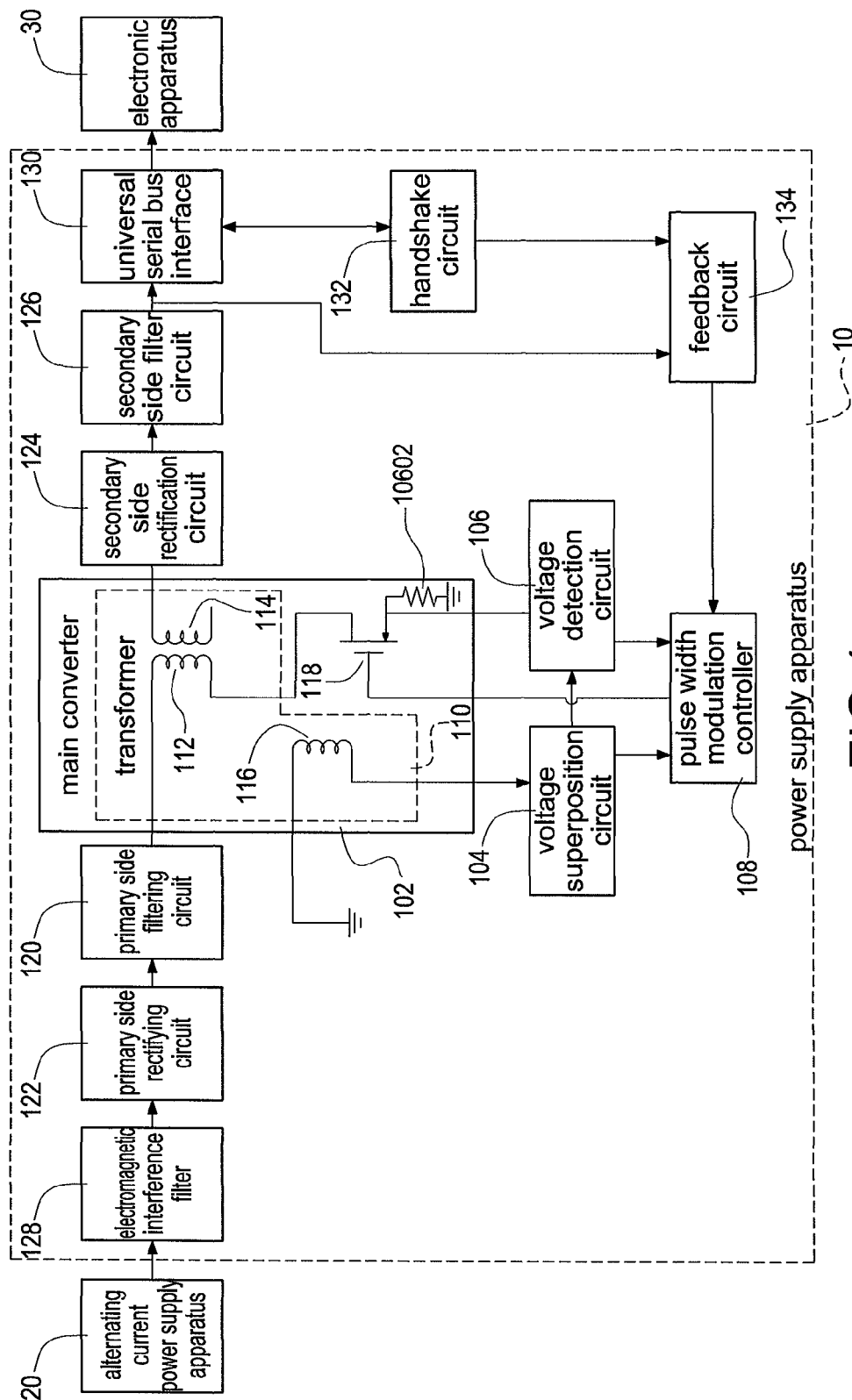


FIG.1

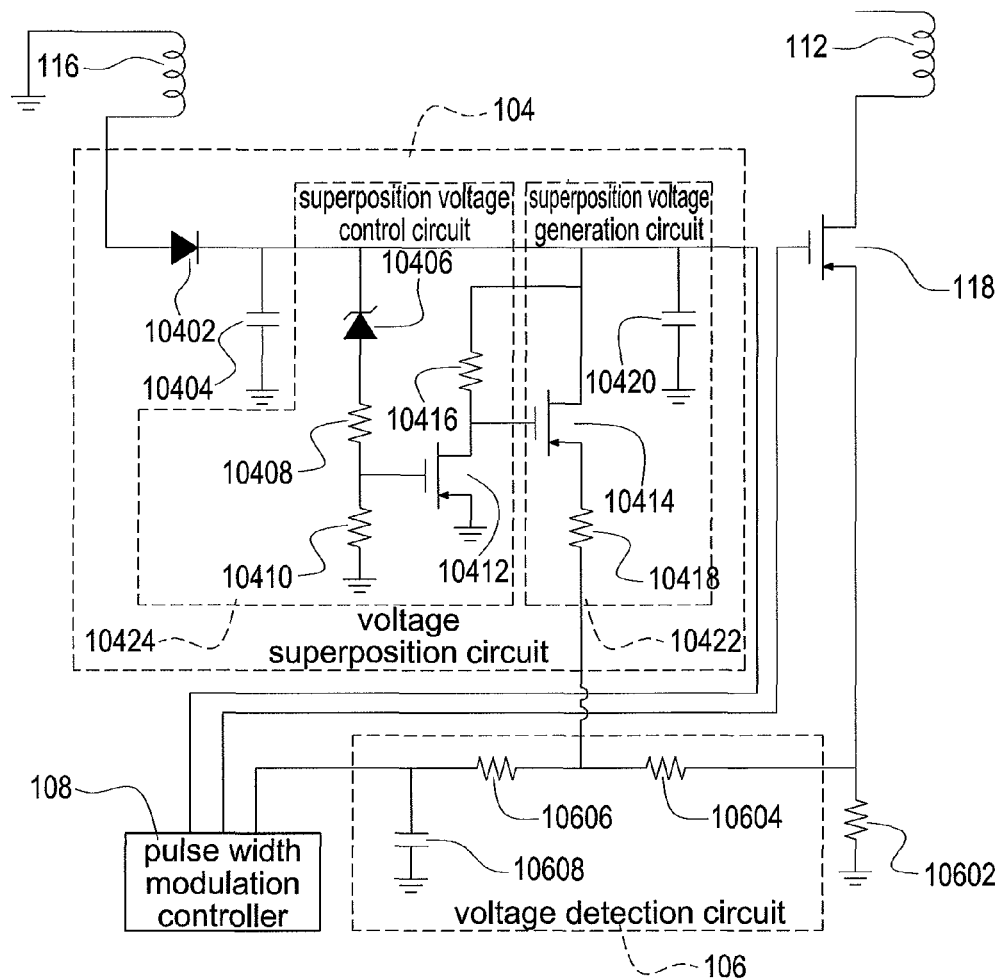


FIG.2

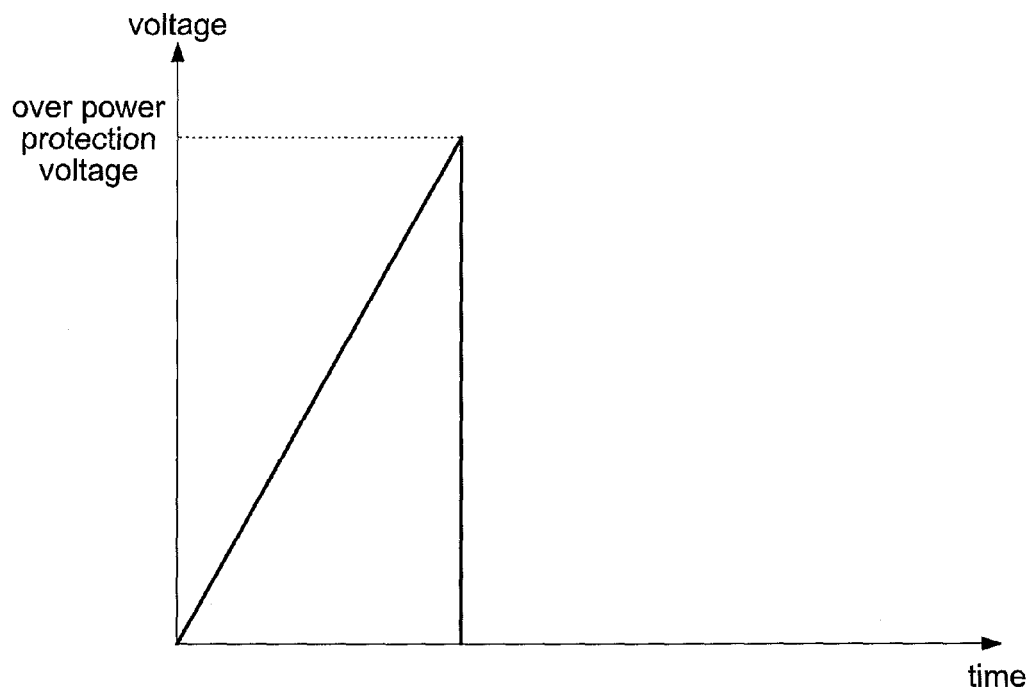


FIG.3

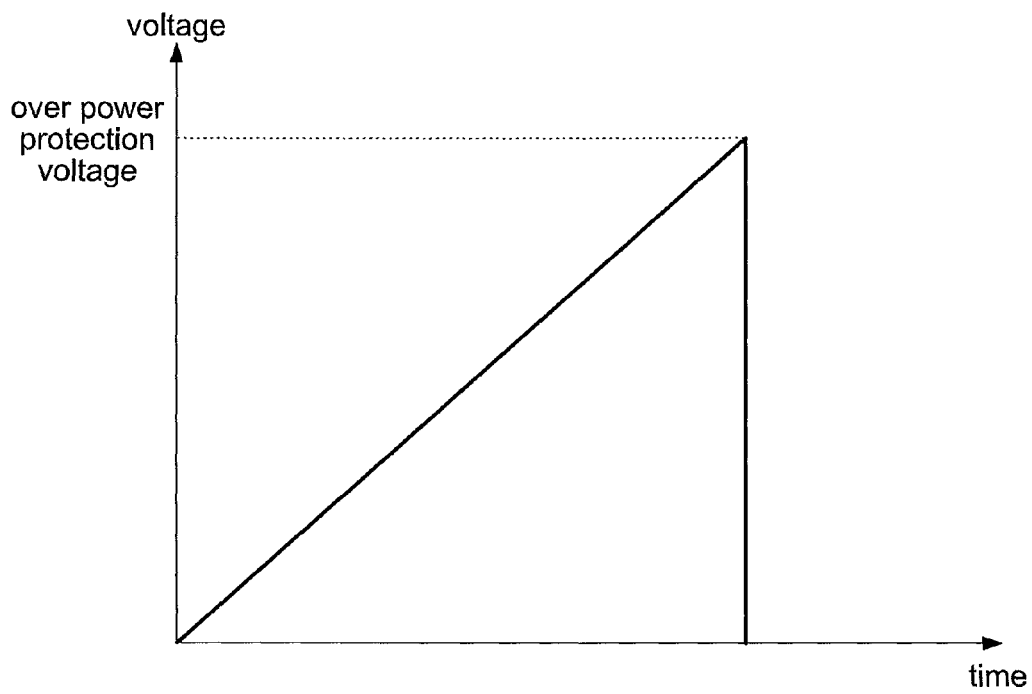


FIG.4

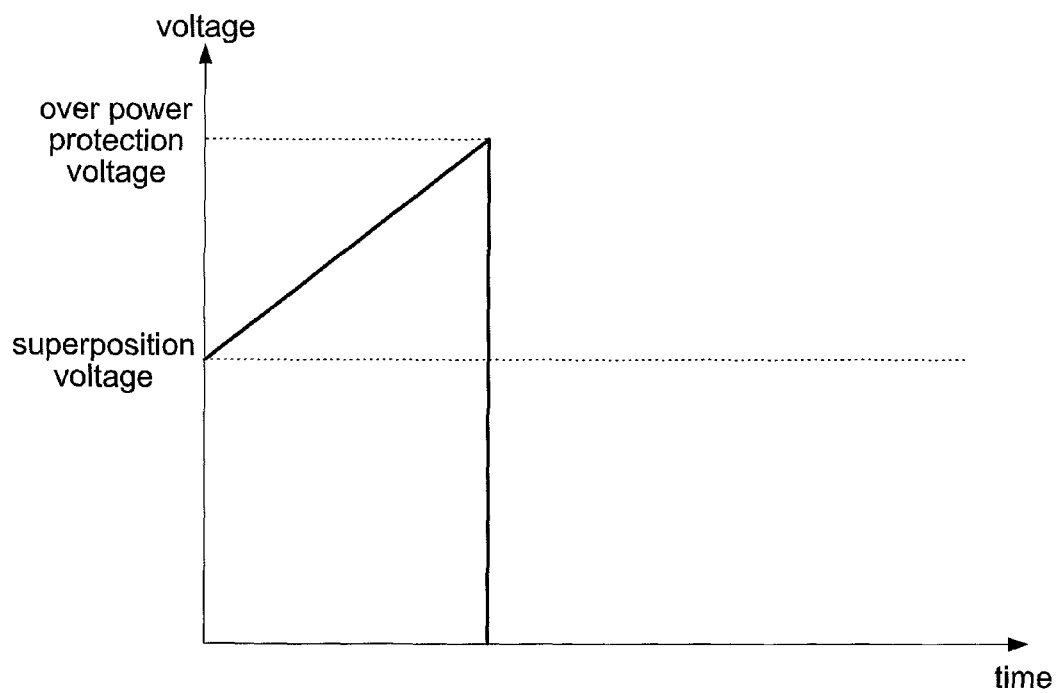


FIG.5

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# FLYBACK APPARATUS WITH VOLTAGE SUPERPOSITION CIRCUIT AND OVERPOWER PROTECTION

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a power supply apparatus, and especially relates to a power supply apparatus with an over power protection function.

### 2. Description of the Related Art

A power supply apparatus supplies power to an electronic apparatus to drive the electronic apparatus. The electronic apparatus informs the power supply apparatus of a required voltage (for examples, 5 volts or 20 volts) if the power supply apparatus supplies power through a universal serial bus interface.

The power supply apparatus comprises a transformer and a pulse width modulation controller. The transformer comprises a primary side winding, an auxiliary winding and a secondary side winding. When the electronic apparatus informs the power supply apparatus of the required voltage, the pulse width modulation controller changes a voltage of the primary side winding, and then the secondary side winding induces the voltage of the primary side winding to generate a voltage to send to the electronic apparatus. At the same time, the auxiliary winding induces the voltage of the secondary side winding to generate a voltage to drive the pulse width modulation controller.

Generally speaking, an output current of the power supply apparatus is limited to about 2 amperes when the power supply apparatus supplies power through the universal serial bus interface. Therefore, an output power of the power supply apparatus is limited. An output voltage of the power supply apparatus is increased to increase the output power of the power supply apparatus in a circumstance that the output current of the power supply apparatus is limited. For example, the output voltage of the power supply apparatus is increased from 5 volts to 20 volts.

Moreover, an over power protection function of the power supply apparatus is constant. Namely, the over power protection function of the power supply apparatus is designed for the output voltage 5 volts or 20 volts. The over power protection function of the power supply apparatus cannot operate smoothly when the output voltage of the power supply apparatus is 5 volts but the over power protection function of the power supply apparatus is designed for the output voltage 20 volts.

FIG. 3 shows a waveform diagram of the related art power supply apparatus that the over power protection function is designed for the output voltage 20 volts. FIG. 4 shows a waveform diagram of the related art power supply apparatus that the over power protection function is designed for the output voltage 5 volts. A trigger level of the over power protection function of the output voltage 5 volts is the same with a trigger level of the over power protection function of the output voltage 20 volts, so the output current of the output voltage 5 volts has to be greater than the output current of the output voltage 20 volts to achieve the trigger level of the over power protection function (the voltage times the current is equal to the power). However, if the output current is greater, power components in the power supply apparatus will work in a condition greater than a rated voltage or a rated current, so that the power components are damaged easily.

## SUMMARY OF THE INVENTION

In order to solve the above-mentioned problems, an object of the present invention is to provide a power supply apparatus with an over power protection function.

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In order to achieve the object of the present invention mentioned above, the power supply apparatus comprises a main converter, a voltage superposition circuit, a voltage detection circuit and a pulse width modulation controller. The voltage superposition circuit is electrically connected to the main converter. The voltage detection circuit is electrically connected to the main converter and the voltage superposition circuit. The pulse width modulation controller is electrically connected to the main converter and the voltage detection circuit. The main converter comprises a sensing resistor electrically connected to the voltage detection circuit. The voltage detection circuit detects a sensing voltage of the sensing resistor. The voltage superposition circuit supplies a superposition voltage to the voltage detection circuit when an output voltage of the power supply apparatus is less than a predetermined output voltage, and then the voltage detection circuit sends the sensing voltage and the superposition voltage to the pulse width modulation controller. The pulse width modulation controller is configured to turn off the main converter when the sensing voltage plus the superposition voltage is greater than an over power protection voltage.

The advantage of the present invention is that the over power protection function of the power supply apparatus can operate smoothly no matter what the output voltage of the power supply apparatus is. The circuits increased in the power supply apparatus are cheap and arranged at the primary side of the power supply apparatus.

## BRIEF DESCRIPTION OF DRAWING

FIG. 1 shows a block diagram of the power supply apparatus of the present invention.

FIG. 2 shows a circuit diagram of an embodiment of the voltage superposition circuit and the voltage detection circuit of the present invention.

FIG. 3 shows a waveform diagram of the related art power supply apparatus that the over power protection function is designed for the output voltage 20 volts.

FIG. 4 shows a waveform diagram of the related art power supply apparatus that the over power protection function is designed for the output voltage 5 volts.

FIG. 5 shows a waveform diagram of the power supply apparatus of the present invention that the over power protection function is designed for the output voltage 5 volts.

## DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a block diagram of the power supply apparatus of the present invention. A power supply apparatus 10 with an over power protection function is applied to an alternating current power supply apparatus 20 and an electronic apparatus 30.

The power supply apparatus 10 comprises a main converter 102, a voltage superposition circuit 104, a voltage detection circuit 106, a pulse width modulation controller 108, a primary side filtering circuit 120, a primary side rectifying circuit 122, a secondary side rectifying circuit 124, a secondary side filtering circuit 126, an electromagnetic interference filter 128, a universal serial bus interface 130, a handshake circuit 132 and a feedback circuit 134.

The main converter 102 comprises a transformer 110, a transistor switch 118 and a sensing resistor 10602. The transformer 110 comprises a primary side winding 112, a secondary side winding 114 and an auxiliary winding 116. The transistor switch 118 is, for example but not limited to, a metal oxide semiconductor field effect transistor.

The voltage superposition circuit **104** is electrically connected to the main converter **102**. The voltage detection circuit **106** is electrically connected to the main converter **102** and the voltage superposition circuit **104**. The pulse width modulation controller **108** is electrically connected to the main converter **102** and the voltage detection circuit **106**. The transformer **110** is electrically connected to the voltage superposition circuit **104**, the pulse width modulation controller **108** and the sensing resistor **10602**. The transistor switch **118** is electrically connected to the primary side winding **112**, the voltage detection circuit **106**, the pulse width modulation controller **108** and the sensing resistor **10602**. The auxiliary winding **116** is electrically connected to the voltage superposition circuit **104**.

The primary side filtering circuit **120** is electrically connected to the primary side winding **112**. The primary side rectifying circuit **122** is electrically connected to the primary side filtering circuit **120**. The secondary side rectifying circuit **124** is electrically connected to the secondary side winding **114**. The secondary side filtering circuit **126** is electrically connected to the secondary side rectifying circuit **124**. The electromagnetic interference filter **128** is electrically connected to the primary side rectifying circuit **122** and the alternating current power supply apparatus **20**.

The universal serial bus interface **130** is electrically connected to the secondary side filtering circuit **126** and the electronic apparatus **30**. The handshake circuit **132** is electrically connected to the universal serial bus interface **130**. The feedback circuit **134** is electrically connected to the handshake circuit **132**, the secondary side filtering circuit **126**, the universal serial bus interface **130** and the pulse width modulation controller **108**. The sensing resistor **10602** is electrically connected to the voltage detection circuit **106**.

FIG. 2 shows a circuit diagram of an embodiment of the voltage superposition circuit and the voltage detection circuit of the present invention. The voltage superposition circuit **104** comprises a superposition voltage generation circuit **10422**, a superposition voltage control circuit **10424**, a first diode **10402** and a first capacitor **10404**. The superposition voltage generation circuit **10422** is electrically connected to the voltage detection circuit **106**. The superposition voltage control circuit **10424** is electrically connected to the superposition voltage generation circuit **10422** and the auxiliary winding **116** of the transformer **110**.

When an output voltage of the power supply apparatus **10** is less than a predetermined output voltage, the superposition voltage control circuit **10424** is configured to turn on the superposition voltage generation circuit **10422**, so that the voltage superposition circuit **10422** supplies a superposition voltage to the voltage detection circuit **106**. The first diode **10402** and the first capacitor **10404** are used to perform filtering.

The superposition voltage control circuit **10424** comprises a first Zener diode **10406**, a first resistor **10408**, a second resistor **10410**, a first metal oxide semiconductor field effect transistor **10412** and a third resistor **10416**. The superposition voltage generation circuit **10422** comprises a second metal oxide semiconductor field effect transistor **10414**, a fourth resistor **10418** and a second capacitor **10420**.

The first diode **10402** is electrically connected to the auxiliary winding **116** and the pulse width modulation controller **108**. The first capacitor **10404** is electrically connected to the first diode **10402** and the pulse width modulation controller **108**. The first Zener diode **10406** is electrically connected to the first diode **10402** and the pulse width modulation controller **108**.

The first resistor **10408** is electrically connected to the first Zener diode **10406**. The second resistor **10410** is electrically connected to the first resistor **10408**. The first metal oxide semiconductor field effect transistor **10412** is electrically connected to the first resistor **10408**. The second metal oxide semiconductor field effect transistor **10414** is electrically connected to the first diode **10402**, the first metal oxide semiconductor field effect transistor **10412** and the pulse width modulation controller **108**.

The third resistor **10416** is electrically connected to the first diode **10402**, the first metal oxide semiconductor field effect transistor **10412**, the second metal oxide semiconductor field effect transistor **10414** and the pulse width modulation controller **108**. The fourth resistor **10418** is electrically connected to the second metal oxide semiconductor field effect transistor **10414** and the voltage detection circuit **106**. The second capacitor **10420** is electrically connected to the first diode **10402**, the second metal oxide semiconductor field effect transistor **10414** and the pulse width modulation controller **108**. The second capacitor **10420** is used for supplying power to the pulse width modulation controller **108**.

In another word, an anode of the first diode **10402** is connected to the auxiliary winding **116**. A cathode of the first diode **10402** is connected to the pulse width modulation controller **108**. One side of the first capacitor **10404** is connected to the cathode of the first diode **10402** and the pulse width modulation controller **108**. The other side of the first capacitor **10404** is connected to ground. A cathode of the first Zener diode **10406** is connected to the cathode of the first diode **10402**, one side of the first capacitor **10404** and the pulse width modulation controller **108**. One side of the first resistor **10408** is connected to an anode of the first Zener diode **10406**. One side of the second resistor **10410** is connected to the other side of the first resistor **10408**. The other side of the second resistor **10410** is connected to ground.

A gate of the first metal oxide semiconductor field effect transistor **10412** is connected to the other side of the first resistor **10408** and one side of the second resistor **10410**. A source of the first metal oxide semiconductor field effect transistor **10412** is connected to ground. A gate of the second metal oxide semiconductor field effect transistor **10414** is connected to a drain of the first metal oxide semiconductor field effect transistor **10412**. A drain of the second metal oxide semiconductor field effect transistor **10414** is connected to the cathode of the first diode **10402**, one side of the first capacitor **10404**, the cathode of the first Zener diode **10406** and the pulse width modulation controller **108**.

One side of the third resistor **10416** is connected to the cathode of the first diode **10402**, one side of the first capacitor **10404**, the cathode of the first Zener diode **10406**, the drain of the second metal oxide semiconductor field effect transistor **10414** and the pulse width modulation controller **108**. The other side of the third resistor **10416** is connected to the drain of the first metal oxide semiconductor field effect transistor **10412** and the gate of the second metal oxide semiconductor field effect transistor **10414**. One side of the fourth resistor **10418** is connected to a source of the second metal oxide semiconductor field effect transistor **10414**. The other side of the fourth resistor **10418** is connected to the voltage detection circuit **106**. One side of the second capacitor **10420** is connected to the cathode of the first diode **10402**, one side of the first capacitor **10404**, the cathode of the first Zener diode **10406**, the drain of the second metal oxide semiconductor field effect transistor **10414**, one side of the third resistor **10416** and the pulse width modulation controller **108**. The other side of the second capacitor **10420** is connected to ground.

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The voltage detection circuit **106** comprises a fifth resistor **10604**, a sixth resistor **10606** and a third capacitor **10608**. The fifth resistor **10604** is electrically connected to the transistor switch **118**, the fourth resistor **10418** and the sensing resistor **10602**. The sixth resistor **10606** is electrically connected to the fourth resistor **10418**, the fifth resistor **10604** and the pulse width modulation controller **108**. The third capacitor **10608** is electrically connected to the sixth resistor **10606** and the pulse width modulation controller **108**.

In another word, one side of the sensing resistor **10602** is connected to the transistor switch **118**. The other side of the sensing resistor **10602** is connected to ground. One side of the fifth resistor **10604** is connected to the transistor switch **118** and one side of the sensing resistor **10602**. The other side of the fifth resistor **10604** is connected to the other side of the fourth resistor **10418**. One side of the sixth resistor **10606** is connected to the other side of the fourth resistor **10418** and the other side of the fifth resistor **10604**. The other side of the sixth resistor **10606** is connected to the pulse width modulation controller **108**. One side of the third capacitor **10608** is connected to the pulse width modulation controller **108** and the other side of the sixth resistor **10606**. The other side of the third capacitor **10608** is connected to ground.

Please refer to FIG. 1 and FIG. 2 at the same time. The electronic apparatus **30** informs the pulse width modulation controller **108** of a required voltage (for examples, 5 volts or 20 volts) through the universal serial bus interface **130**, the handshake circuit **132** and the feedback circuit **134**. Therefore, the pulse width modulation controller **108** is configured to control the transistor switch **118** to change a primary side winding voltage of the primary side winding **112**. Moreover, the main converter **102** is, for example but not limited to, a flyback converter. The pulse width modulation controller **108** controlling the transistor switch **118** to change the primary side winding voltage of the primary side winding **112** is a prior art, which is not described here for brevity.

The voltage detection circuit **106** detects a sensing voltage of the sensing resistor **10602**. The voltage detection circuit **106** informs the pulse width modulation controller **108** of the sensing voltage. The over power protection function of the power supply apparatus **10** (the pulse width modulation controller **108**) is designed for the required voltage 20 volts. Therefore, the over power protection function can operate smoothly when the required voltage is 20 volts.

How the over power protection function can operate smoothly as well when the required voltage is 5 volts will be described as following.

An auxiliary winding voltage of the auxiliary winding **116** is, for example, 80 volts when the required voltage is 20 volts. The auxiliary winding voltage of the auxiliary winding **116** is, for example, 20 volts when the required voltage is 5 volts. It is a prior art and is not described here for brevity.

A breakdown voltage of the first Zener diode **10406** is a predetermined voltage, greater than 20 volts but less than 80 volts, for example, 40 volts. Therefore, when the auxiliary winding voltage is 80 volts (the required voltage is 20 volts), the first metal oxide semiconductor field effect transistor **10412** is turned on and the second metal oxide semiconductor field effect transistor **10414** is turned off, so that the auxiliary winding voltage is not sent to the voltage detection circuit **106**.

The voltage detection circuit **106** sends the sensing voltage to the pulse width modulation controller **108**. The pulse width modulation controller **108** is configured to determine whether the over power protection function is performed or not. This

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is the original over power protection function of the power supply apparatus **10** (the pulse width modulation controller **108**).

When the auxiliary winding voltage (20 volts) of the main converter **102** (the auxiliary winding **116**) is less than the predetermined voltage 40 volts (the required voltage is 5 volts), the first metal oxide semiconductor field effect transistor **10412** is turned off and the second metal oxide semiconductor field effect transistor **10414** is turned on, so that the auxiliary winding voltage is sent to the voltage detection circuit **106**.

In another word, the voltage superposition circuit **104** provides the superposition voltage (namely, the auxiliary winding voltage) to the voltage detection circuit **106**, and then the voltage detection circuit **106** sends the sensing voltage and the superposition voltage to the pulse width modulation controller **108**. Therefore, the pulse width modulation controller **108** is configured to determine whether the over voltage (power) protection function is performed or not. Namely, the pulse width modulation controller **108** is configured to turn off the main converter **102** when the sensing voltage plus the superposition voltage is greater than an over power protection voltage.

The pulse width modulation controller **108** receives the sensing voltage and the superposition voltage (not just only the sensing voltage) when the required voltage is 5 volts. The sensing voltage received by the pulse width modulation controller **108** is raised with the superposition voltage to trigger the over power protection function correctly, so that the over power protection function can operate smoothly.

Namely, the voltage superposition circuit **104** provides the superposition voltage to the voltage detection circuit **106** when the output voltage (for example, 5 volts) of the power supply apparatus **10** is less than the predetermined output voltage (for example, 10 volts).

The superposition voltage mentioned in above embodiment is the auxiliary winding voltage. However, the present invention is not limited to it. The superposition voltage can be a voltage source arranged in the primary side or the secondary side of the power supply apparatus **10** as well. The voltage source is connected to the drain of the second metal oxide semiconductor field effect transistor **10414**, one side of the third resistor **10416** and one side of the second capacitor **10420**. However, the voltage source is not connected to the cathode of the first diode **10402**, one side of the first capacitor **10404** and the cathode of the first Zener diode **10406**. In another word, the circuit shown in FIG. 2 has to be modified.

FIG. 5 shows a waveform diagram of the power supply apparatus of the present invention that the over power protection function is designed for the output voltage 5 volts. The slope of the voltage shown in FIG. 5 is basically equal to the slope of the voltage shown in FIG. 4. The voltage shown in FIG. 5 is raised with the superposition voltage. A voltage of the third capacitor **10608** is raised when the output current of the power supply apparatus **10** is raised. Therefore, comparing to FIG. 4, the power supply apparatus **10** has correct over power protection function due to the compensation mechanism shown in FIG. 5, to avoid power components of the power supply apparatus **10** working in the condition greater than the rated voltage or the rated current.

Although the content mentioned above is described for the voltage, the current can be derived from the voltage, and the voltage multiplied by the current equals the power. Therefore, the over power protection is similar to the over voltage protection in the present invention. The advantage of the present invention is that the over power protection function of the power supply apparatus **10** can operate smoothly no matter



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what the output voltage of the power supply apparatus **10** is (for examples, 5 volts or 20 volts mentioned above). The circuits increased in the power supply apparatus **10** are cheap and arranged at the primary side of the power supply apparatus **10**.

The present invention can protect the transformer **110** and the electronic apparatus **30**. The pulse width modulation controller **108** turns off the transistor switch **118** to protect the power supply apparatus **10** and the electronic apparatus **30** when the voltage detection circuit **106** detects that the voltage (current) achieves the over current protection. Namely, the pulse width modulation controller **108** controls (turns on or turns off) the transistor switch **118** according to the voltage sent from the voltage detection circuit **106** to the pulse width modulation controller **108**.

Although the present invention has been described with reference to the preferred embodiment thereof, it will be understood that the invention is not limited to the details thereof. Various substitutions and modifications have been suggested in the foregoing description, and others will occur to those of ordinary skill in the art. Therefore, all such substitutions and modifications are intended to be embraced within the scope of the invention as defined in the appended claims.

What is claimed is:

**1.** A power supply apparatus with an over power protection function, the power supply apparatus comprising:

- a main converter;
- a voltage superposition circuit electrically connected to the main converter;
- a voltage detection circuit electrically connected to the main converter and the voltage superposition circuit; and
- a pulse width modulation controller electrically connected to the main converter and the voltage detection circuit, wherein the main converter comprises a sensing resistor electrically connected to the voltage detection circuit; wherein the voltage detection circuit detects a sensing voltage of the sensing resistor; the voltage superposition circuit supplies a superposition voltage to the voltage detection circuit when an output voltage of the power supply apparatus is less than a predetermined output voltage, and then the voltage detection circuit sends the sensing voltage and the superposition voltage to the pulse width modulation controller; the pulse width modulation controller is configured to turn off the main converter when the sensing voltage plus the superposition voltage is greater than an over power protection voltage.

**2.** The power supply apparatus in claim **1**, wherein the voltage superposition circuit comprises:

- a superposition voltage generation circuit electrically connected to the voltage detection circuit; and
- a superposition voltage control circuit electrically connected to the superposition voltage generation circuit and the transformer,

wherein when the output voltage is less than the predetermined output voltage, the superposition voltage control circuit is configured to turn on the superposition voltage generation circuit, so that the superposition voltage generation circuit supplies the superposition voltage to the voltage detection circuit.

**3.** The power supply apparatus in claim **2**, wherein the main converter further comprises:

- a transformer electrically connected to the voltage superposition circuit, the pulse width modulation controller and the sensing resistor,

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wherein the transformer comprises:

- a primary side winding;
- a secondary side winding; and
- an auxiliary winding electrically connected to the voltage superposition circuit.

**4.** The power supply apparatus in claim **3**, wherein the main converter further comprises a transistor switch electrically connected to the primary side winding, the voltage detection circuit and the pulse width modulation controller.

**5.** The power supply apparatus in claim **4**, wherein the voltage superposition circuit further comprises:

- a first diode electrically connected to the auxiliary winding and the pulse width modulation controller; and
- a first capacitor electrically connected to the first diode and the pulse width modulation controller,

wherein the superposition voltage control circuit comprises:

- a first zener diode electrically connected to the first diode and the pulse width modulation controller.

**6.** The power supply apparatus in claim **5**, wherein the superposition voltage control circuit further comprises:

- a first resistor electrically connected to the first zener diode;
- a second resistor electrically connected to the first resistor;
- a first metal oxide semiconductor field effect transistor electrically connected to the first resistor; and
- a third resistor electrically connected to the first diode, the first metal oxide semiconductor field effect transistor and the pulse width modulation controller.

**7.** The power supply apparatus in claim **6**, wherein the superposition voltage generation circuit comprises:

- a second metal oxide semiconductor field effect transistor electrically connected to the first diode, the first metal oxide semiconductor field effect transistor and the pulse width modulation controller;
- a fourth resistor electrically connected to the second metal oxide semiconductor field effect transistor and the voltage detection circuit; and
- a second capacitor electrically connected to the first diode, the second metal oxide semiconductor field effect transistor and the pulse width modulation controller.

**8.** The power supply apparatus in claim **7**, wherein the voltage detection circuit comprises:

- a fifth resistor electrically connected to the transistor switch, the fourth resistor and the sensing resistor;
- a sixth resistor electrically connected to the fourth resistor, the fifth resistor and the pulse width modulation controller; and
- a third capacitor electrically connected to the sixth resistor and the pulse width modulation controller.

**9.** The power supply apparatus in claim **8**, further comprising:

- a primary side filtering circuit electrically connected to the primary side winding;
- a primary side rectifying circuit electrically connected to the primary side filtering circuit;
- a secondary side rectifying circuit electrically connected to the secondary side winding; and
- a secondary side filtering circuit electrically connected to the secondary side rectifying circuit.

**10.** The power supply apparatus in claim **9**, the power supply apparatus applied to an alternating current power supply apparatus and an electronic apparatus, the power supply apparatus further comprising:

- an electromagnetic interference filter electrically connected to the primary side rectifying circuit and the alternating current power supply apparatus;

a universal serial bus interface electrically connected to the secondary side filtering circuit and the electronic apparatus;  
a handshake circuit electrically connected to the universal serial bus interface; and  
a feedback circuit electrically connected to the handshake circuit, the secondary side filtering circuit, the universal serial bus interface and the pulse width modulation controller.

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